

THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[SIXTH SERIES.]

“..... per litora spargite muscum,
Naiades, et circum vitreos considite fontes:
Pollice virgineo teneros hic carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas;
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchyliis succo.”
N. Parthenii Giannettasii Pcl. l.

No. 31. JULY 1890.

I.—*On certain Points in the Anatomical Nomenclature of Echinoderms.* By P. HERBERT CARPENTER, D.Sc., F.R.S., F.L.S., Assistant Master at Eton College.

THE object of the following paper is to put in a plea for a greater precision of nomenclature in works on Echinoderm morphology than has been hitherto adopted by many authors, more especially those who have made incidental rather than special studies in some branch of Echinoderm research. Many of them are justly distinguished in other lines of scientific work; but, owing to their imperfect acquaintance with the current Echinoderm literature, a vagueness and inaccuracy of nomenclature have crept into their writings in a manner which is both perplexing to the student and vexatious to the specialist.

I refer more especially to the frequent use of the same term for two or more structures which are not mutually homologous*, while, on the other hand, there are some cases in

* Since writing the above lines I have come across the following remarks by Hérouard on the same subject:—“Ce sont là des questions de détail, il est vrai, mais sur lesquelles j'insiste à dessein, car ces dénominations identiques attribuées par les différents auteurs et même parfois, comme je viens de le dire, par un seul et même auteur, à des organes

which homologies are universally recognized, though the fact does not appear in the nomenclature.

1. *The use of the term "Water-tube."*

The term "water-tube" seems to have been first used by A. Agassiz* for the two cœlomic diverticula of the archenteron in the Starfish-larva, this being "the name which denotes most appropriately the function they assume of circulating water through the body of the larva." He also applied the same name † to the gills or "papulæ" of Stimpson and Sladen, which are not developed till much later; but the first meaning which he gave to the term has not found acceptance in Europe, especially since the morphological importance of these water-tubes has been more fully realized, and they have been variously known as the cœlomic pouches, vaso-peritoneal sacs, &c.; while "water-tube" or "tube hydrophore" has been largely used by both English and French writers instead of the misleading term "sand-canal" or "stone-canal," which is so often totally inapplicable to the structure it is supposed to designate. In America, however, Brooks ‡ and Fewkes have continued to speak of the water-tubes of the Echinoderm-larva, and they use the same term when referring to the organs which are described as circular and radial water-vessels by European writers. This course seems likely to lead to much confusion, the more so as one at least, and sometimes both, of the larval cœlomic pouches do not in any way give rise to the "water-tubes" of the ambulacral system. Fewkes is an especial offender in this respect, for in his last publication but one he uses the term water-tube with different meanings on two successive lines §:—"Each of the five small *culs-de-sac*, *r w*, from the water tube on the ambulacral side of the young starfish forms a radial water tube of the starfish." Five pages later he says that the stone-canal is an internal calcifi-

différents, créent, dans l'esprit du lecteur, une confusion pénible qu'il est parfois difficile d'éclaircir par une seule lecture et qui a contribué, pour une large part, à faire prendre dans certains cas, comme divergentes, des opinions qui ne différaient pas sensiblement l'une de l'autre" ("Recherches sur les Holothuries des Côtes de France," Arch. Zool. Exp. et Gén. vol. vii. 1889, p. 630).

* 'Embryology of the Starfish,' 1864. Reprinted in "North American Starfishes," Mem. Mus. Comp. Zoöl. 1877, vol. v. p. 13.

† *Ibid.* p. 52.

‡ 'Handbook of Invertebrate Zoology,' Boston, 1882, pp. 72, 135.

§ "On the Development of the Calcareous Plates of *Asterias*," Bull. Mus. Comp. Zoöl. 1888, vol. xvii. p. 7.

cation which "arises in the walls of the water tube," thus giving a third meaning to the same term, while Agassiz, as we have seen, has used it in yet another sense. Is it too much to ask on behalf of the student of the future that it be employed in one sense only? In the following pages it will be used to denote the madreporic or stone-canal.

2. Dorsocentral and Centro-dorsal.

These two names are frequently used as if they were synonymous, though in reality they denote plates of very different morphological characters.

The term "dorsocentral" appears to have been first used by the Messrs. Austin* for that part of a Crinoid which was called the pelvis by Miller, *i. e.* the ring of plates which rest upon the top stem-joint. In some cases five separate plates may be distinguished, in others only three, while in others there seems to be but one undivided plate with a stem-facet on its lower surface; and even this facet is absent on the central plate of *Marsupites*. Owing to the rapid spread of the Müllerian terminology, in which the lowest plates of the Crinoidal calyx were designated basals, the collective name "dorsocentral" applied to them by Austin never found general acceptance. But in Lovén's classical work † on the Echini the term "dorsocentral system" is used to denote the central plate in the apex of a young Urchin, together with the two rings of genital and ocular plates around it. He regarded the central plate of *Marsupites* as homologous with that of the Urchin, and also compared the ocular plates of the latter to the radials of *Marsupites*, two determinations which I fully accepted when writing on the subject in 1878 ‡, though I could not follow Lovén in the other homologies which he proposed, nor in his views respecting the primitively compound nature of the dorsocentral plate. I suggested at the same time that the homologue of the latter was to be found in the terminal plate at the base of the stem in the stalked larva of *Comatula*, which I carefully distinguished from the enlarged upper stem-joint or centro-dorsal piece. Sladen § adopted this view in 1884, since which time the

* "Descriptions of several new Genera and Species of Crinoidea," Ann. & Mag. Nat. Hist. 1843, vol. xi. p. 196.

† "Études sur les Échinoïdées," Kongl. Svenska Vetenskaps-Akademiens Handlingar, 1874, Bd. xi. no. 7, p. 65.

‡ "On the Oral and Apical Systems of the Echinoderms," Quart. Journ. Micr. Sci. 1878, vol. xviii. p. 359.

§ "On the Homologies of the Primary Larval Plates in the Test of Brachiata Echinoderms," Quart. Journ. Micr. Sci. 1884, vol. xxiv. p. 25.

central plate of the Echinoderm apical system has been repeatedly noticed by us both and also by others under the name "dorsocentral;" and zoologists have been warned again and again not to confuse it with the enlarged top stem-joint in the stem of many Crinoids, for which, in the case of *Comatula*, Müller and his successors had employed the name "centro-dorsal." Early in 1887 Duncan and Sladen*, writing on the morphology of the Saleniidæ, frequently referred to the so-called sur-anal plate of Echinids as the dorsocentral, mentioning at the same time its homologies in the Asterids and Ophiurids. Fewkes†, who had previously confounded dorsocentral and centro-dorsal, wrote a short time later in the same terms. But all our efforts to obtain a greater precision of nomenclature seem to have been in vain, for even such a well-informed writer as the late Professor Neumayr‡ alluded in 1888 to "die centrodorsale Platte bei Salenien." Unaware, too, that the presence of independent under-basals in the *Antedon*-larva had been announced by Bury§ in 1887, he concluded that they are represented by the "centrale Platte," by which he meant the enlarged top stem-joint or centro-dorsal. But as he also recognized the fact that these under-basals are well developed in *Marsupites* and enclose "eine grosse centrodorsale Tafel," he was driven to the following conclusions ||:—"Es scheint demnach, als ob die centrodorsale Platte der ausgewachsenen Crinoiden durchaus nicht immer dieselbe morphologische Bedeutung hätte, und auch durchaus nicht nothwendig immer dem gleichnamigen Theile der *Antedon*-Larve entspräche." But is it so certain that the central plate in the calyx of *Marsupites* should be called a centro-dorsal at all, *i. e.* that it is an enlarged top stem-joint? Twelve years ago I gave reasons for believing it to be a primitively imperforate plate homologous with the dorsocentral of *Salenia*, and not a top stem-joint with its central canal obscured by a secondary calcareous deposit¶. My arguments have never been refuted; but palæontologists have nevertheless continued to speak of the centro-dorsal of *Mar-*

* "On some Points in the Morphology and Classification of the Saleniidæ, Agassiz," *Ann. & Mag. Nat. Hist.* 1887, ser. 5, vol. xix. pp. 119, 121.

† *Bull. Mus. Comp. Zoöl.* 1888, vol. xvii. p. 38.

‡ 'Die Stämme des Thierreichs,' Wien, 1889, Bd. i. p. 493.

§ "The Early Stages in the Development of *Antedon rosacea*," Report of the Fifty-seventh Meeting of the British Association, held at Manchester, 1887: London, 1888, p. 735. Also *Proc. Roy. Soc.* 1887-88, vol. xliii. p. 299.

|| *Op. cit.* p. 493.

¶ *Quart. Journ. Micr. Sci.* 1878, vol. xviii. pp. 380, 381.

supites, as if its homology were quite undoubted; and it is not surprising therefore that its coexistence with under-basals in that type should have driven Neumayr to the conclusion that something was wrong. *Salenia* has a dorsocentral only. *Marsupites* has a dorsocentral and under-basals. The *Antedon*-larva has a dorsocentral at the bottom of the stem, a centro-dorsal at the top, and under-basals resting upon it. If these facts be carefully borne in mind, much that has seemed so obscure both to Neumayr and to his predecessors receives its proper explanation.

3. Basals and Under-basals.

The nomenclature of the plates forming the dicyclic base in many Crinoids is still somewhat wanting in uniformity and precision. Twelve years ago* I pointed out that the so-called parabasals of the dicyclic Crinoids are the real homologues of the basals in the monocyclic forms, the lower ring of plates in the dicyclic Crinoids being an additional element in the calyx. I proposed to call the latter "under-basals," retaining the name "basals" for the plates immediately below the radials, both in the dicyclic and in the monocyclic forms. Every scientific palæontologist † now admits that the latter plates are homologous throughout the whole series of Crinoids, and the proposed change in the nomenclature has been adopted by the leading writers on Crinoids in this country, Australia, Canada, the United States, France, and Switzerland, and also by Ludwig, the chief German writer on Echinoderms. Zittel ‡, however, while accepting both the homology and the term under-basals, or, as he put it, "infrabasals," believed that the use of the name basals for the upper plates of the dicyclic base would lead to confusion; and so he retained for them the Müllerian name parabasals, thus giving two different names

* *Ibid.* pp. 366, 367.

† Walther, writing in 1886, homologized the infrabasals of Dicyclia with the basals of Monocyclia ("Untersuchungen über den Bau der Crinoiden," *Palæontographica*, 1886, Bd. xxxii. p. 189). His conclusions, however, were largely based upon questions of transcendental morphology which were suggested by his study of the Pentacrinoid larva of *Antedon*. Among them are his remarkable identification of the five primary tentacles of the larva with the clavicular pieces on the radial axillaries of the adult, which has already been noticed in this Journal (ser. 5, vol. xix. p. 88); and as Bury has demonstrated the presence of under-basals in the larva, which were overlooked by Walther, as by all his predecessors, Walther's views respecting the homologies of the basals of the adult *Antedon* and other apparently monocyclic forms are no longer tenable, as he will no doubt admit when he next writes upon the subject.

‡ 'Handbuch der Palæontologie,' Bd. i. pp. 327, 328.

to one and the same set of plates, a method which, as it seems to me, is still more likely to confuse the student. The German palæontologists have naturally followed Zittel, and continue to speak of the dicyclic base as composed of parabasals and infrabasals, a course which will not be made easier by some recent discoveries. Thus, for example, de Loriol has found infrabasals in two species of *Millericrinus**, and the plates above them, hitherto called basals, must now be known as parabasals in these two species, though retaining the simpler name in all the remaining species of the genus. This will be an endless source of confusion, and another is afforded by Zittel's own description of the calyx of *Pentacrinus*. He states that it contains five basals, but adds that five infrabasals are sometimes present. According to his terminology, however, the species possessing them † should have no basals, but parabasals; but he gives no hint of this. Then, again, Bury has recently demonstrated the presence of infrabasals in *Antedon rosacea*; so that in Zittel's terminology the plates hitherto called basals in this type must now be known as parabasals, though their homologues in the apparently monocyclic fossil *Comatule* will retain their old name. In these three genera therefore—*Millericrinus*, *Pentacrinus* (in the widest sense), and *Antedon*—some species are known to be dicyclic, while others are not, though the latter are in all probability only pseudomonocyclic, to use the convenient term proposed by Bather ‡. But in Zittel's terminology the generic diagnosis will have to run somewhat as follows:—"Calyx composed of radials and basals, or of radials, parabasals, and infrabasals." Would it not be infinitely simpler and less confusing to say "Calyx composed of radials and basals, sometimes with the addition of infrabasals"? If this be admitted, it is clear that the same principle may be extended to definitions of families and larger groups, and the misleading term parabasals will then have to be finally abandoned.

The term "subradials" was proposed in 1854 by de Koninck and Le Hon instead of parabasals, and was generally adopted by the leading American palæontologists, *e. g.* Hall, Billings, Meek and Worthen, and Whitfield. As long as the homology of the plates so named with the basals of monocyclic Crinoids remained unrecognized, this name was in

* 'Paléontologie Française,' Terrain Jurassique, tome xi. pt. i. pp. 553, 566.

† These species are now referred to *Extracrinus*.

‡ "British Fossil Crinoids," Ann. & Mag. Nat. Hist. 1890, ser. 6, vol. v. p. 316.

many respects preferable to parabasals. But it was demonstrated in 1878 that the parabasals or subradials of dicyclic Crinoids are the real basal plates, and that the plates hitherto called by that name are an additional element in the calyx, for which the name under-basals was proposed. Messrs. Wachsmuth and Springer adopted this change in Part I. of their 'Revision of the Palæocrinoidea,' which appeared in the following year, and their example has been followed by five writers on Crinoids in the United States, including the late Professor Worthen himself, and two in Canada. With the exception of the late Professor Quenstedt all the continental palæontologists* who have written on Crinoids in general during the last decade have abandoned the use of the term basals for the lower ring of plates in the dicyclic base in favour of under-basals or infrabasals; so that it has really seemed as if the rational system of nomenclature was coming into general use. In America, however, S. A. Miller has steadily declined to adopt it, and he has continued to use the purely empirical terminology of de Koninck. His reasons for this course were stated as follows in 1883:—"Most American authors, and I might say all, until quite recently, have called the plates, in the first ring above the column, the basals, and when the second exists they have called them subradials. Certainly no names can be easier or more expressive. . . . The policy of changing the nomenclature may well be doubted, and ought not to be entered upon without the clearest conviction, that, by so doing, error of some kind is being eradicated" †. In reply to this it was pointed out ‡ that the change had been proposed expressly to avoid the error of giving the same name "basals" to parts which are not homologous in monocyclic and in dicyclic Crinoids respectively. This argument does not seem to have produced any impression upon Miller; for in the useful Catalogue of North American Palæozoic fossils which he has recently published he still uses the term basals for the lowest plates of the dicyclic calyx. The confusion into which he is thus led

* Dalmer, Fritsch, and Wagner describe the dicyclic base of *Encrinus* as composed of inner and outer basals. Neumayr used the same terminology for dicyclic Crinoids generally, with the collective names *basis* and *infrabasis*; but he took especial care to point out that the former and not the latter is homologous with the basis of monocyclic Crinoids.

† "*Glyptocrinus* redefined and restricted, *Gauvocrinus*, *Pycnocrinus*, and *Compsocrinus* established, and two new Species described," Journ. Cincinn. Soc. Nat. Hist. 1883, vol. vi. p. 218.

‡ "On a new Crinoid from the Southern Sea," Phil. Trans. 1883, p. 932.

Date.	Basals and Parabasals.	Basals and Subradials.	Under-basals and Basals.	Infrabasals and Parabasals.	
1841. 1854. 1876.	Müller.	de Kominck & Le Hon.	Carpenter.		
1878.		Oehlert.			Abandoned, 1882.
1879.	<i>Beyrick.</i> von Koenen.	S. A. Miller. <i>Ulrich.</i> Wetherby.	Wachsmuth & Springer. Wetherby.		Abandoned, 1887. Abandoned, 1880.
1880.		<i>White.</i> <i>Grant.</i>		Zittel.	
1881.			de Lorient. Oehlert.	C. Barrois.	Abandoned, 1882.
1882.	Trautschold.	<i>Whitfield.</i>	H. S. Williams. Gandry. Walcott.	Studer. Trautschold *.	
1883.		Worthen.			Abandoned, 1884.

1884.			Worthen. W. R. Billings.	Fraipont.	Abandoned, 1886.
1885.		Ratte.		Waagen.	
1886.	Quenstedt.		Ludwig.		
		Ringueberg.	Ratte.	Walther. Follmann.	Abandoned, 1888.
1887.			von Koenen. Bury.	Eck.	
1888.			Neumayr. Ringueberg.	Steinmann & Döderlein.	
1889. 1890.		Miller & Gurley.	Whiteaves. Bather. Nicholson.		

The authors whose names are in italics have not written on dicyclic Crinoids since 1882.

A comparison of the second with the last two columns shows that Miller's nomenclature is not so "well established" as he appears to think.

* Trautschold (Bull. Soc. Imp. Nat. de Moscou, tom. lvii. 1882 (1883), pp. 201-203) has proposed the name "supra-basals" instead of "parabasals." For some remarks on this question see Quart. Journ. Micr. Sci. vol. xxiv. 1884, pp. 19, 20.

will be evident from the following passage * :—“ Carpenter and Wachsmuth call the ‘subradials’ the ‘basals’ in all cases where they occur, and the lower plates ‘under-basals;’ but where there are no ‘subradials’ they follow the well-established nomenclature in calling the first circle of plates ‘basals.’ ” These very plates, however, are recognized by other palæontologists as representing the subradials, which Miller says are not found in monocyclic Crinoids. It is unfortunate that a work which is likely to be so generally used by students and collectors should in this respect be some years behind the times. The only American writers on Crinoids besides Miller † who have not yet publicly adopted the rational nomenclature are Hall, Grant, Ulrich, White, and Whitfield; but I am not aware that any one of them has written on dicyclic Crinoids since 1882, so that they have had no need to make a decision. One would have thought that the conversion in succession of Messrs. Wetherby, Worthen, and Ringueberg would have led Miller to reconsider his position, which is at present a somewhat isolated one, as is shown in the accompanying table (pp. 8 and 9); and he cannot therefore any longer claim to be using “the established or prevailing methods of description” as he did in 1883.

I have endeavoured to show that the German palæontologists do not always employ the term basals when they might advantageously do so. Fewkes, on the other hand, has used it too freely. Referring to certain plates which appear on the abactinal hemisome of the young *Amphiura*, he says that they “form in the interradii, and may therefore be called interradians or basals;” ‡ and he continues:—“The first set of interradian plates may be known as the abaxial basals or first interradians.” In the next line these are called “abaxial interradians,” and a little further on (p. 130) he mentions a new plate as “beginning to form between an abaxial and an adaxial interradian.” Replying to my criticisms on the looseness of his terminology § and the way in which he has confused terms which previous writers on Crinoid morphology

* ‘North American Geology and Palæontology,’ Cincinnati, 1889, p. 212.

† Since the above was written Messrs. Miller and Gurley have published descriptions of some new Crinoids, in which the term subradials is still employed—“Description of some new Genera and Species of Echinodermata from the Coal measures and Subcarboniferous rocks of Indiana, Missouri, and Iowa,” Journ. Cincinn. Soc. Nat. Hist. 1890, vol. xiii. p. 3.

‡ “On the Development of the Calcareous Plates of *Amphiura*,” Bull. Mus. Comp. Zool. 1887, vol. xiii. p. 128.

§ “On the Development of the Apical Plates in *Amphiura squamata*,” Quart. Journ. Micr. Sci. 1887, vol. xxviii. p. 313.

had endeavoured to keep distinct as denoting different structures, he denies that he has anywhere made use of the combination "adaxial interradians," and implies that I have criticised him unfairly*. The combination does occur, however, but in the singular number, on p. 130 of his paper, as I have quoted above, though he seems to have entirely forgotten his use of it.

He also attempts to justify himself by stating that "Sladen in considering certain starfishes uses interradian for basal, and to explain what he means by interradians uses the following combination:—'interradians (*i. e.* basals).'" I am sorry to say, however, that Fewkes is again in error, and that he has not quoted Sladen correctly. He does not seem to have appreciated the fact that the whole point of my criticism related to his use of the words interradian and basal as substantives with identical meanings, and he quotes Sladen as having done so. Sladen's expression, however, is "interradian (*i. e.* basal) plate" †. Of course the basal plates are interradian, *i. e.* situated between the rays; but they are not *interradians* as this term has been understood by students of the Crinoidea since the time of Müller, and Sladen did not call them so, though Fewkes did.

The question is not a very important one; but I cannot help thinking it desirable that terms which have a very definite meaning in the anatomy of one type should only be applied to homologous parts in descriptions of other types; and when Fewkes writes about the "abaxial basal" or "adaxial interradian" of an Ophiurid it appears to me that he is placing needless obstacles in the way of the students of a subject which already bristles with difficulties.

4. The Radial Plates.

The name "Radialia" was given by Müller to all the plates situated in the direction of the rays between the basals and the first axillary (inclusive) of a Crinoid with more than five arms. His terminology was employed by Roemer, Beyrich, de Koninck, and other writers till the time of Schultze, who modified it very considerably ‡. He adopted the principle that the lowest articular facet indicates the boundary-line between radials and brachials. In his diagrams of *Taocrinus*, *Zeacrinus*, *Rhodocrinus*, and *Actinocrinus* the first

* Bull. Mus. Comp. Zoöl. 1888, vol. xvii. p. 45.

† Quart. Journ. Micr. Sci. 1884, vol. xxiv. p. 33.

‡ "Monographie der Echinodermen des Eißer Kalkes," Denkschr. k. Akad. Wissensch. Wien, 1867, Bd. xxvi. Abth. 2, p. 117.

axillary is the third plate above the basal ring. But whereas Müller would have described each type as having three radials, Schultze said that this is only the case in *Actinocrinus* and *Rhodocrinus*, while *Taxocrinus* and *Zeacrinus* have but one radial followed by two brachials, of which the second is axillary. In the first two parts of the 'Revision of the Palæocrinoidea' Messrs. Wachsmuth and Springer used the expression primary radials for the ray-plates in the body up to the first axillary, *i. e.* the radials of Müller, while the following body-plates up to the next axillary (distichals of Müller) were called secondary radials, and so on, the term "brachials" being used to denote "free radial plates supporting the arms"*. At the same time, however, the American authors suggested that the arms fundamentally commence with the plates above the first radials, whether these be free or incorporated into the calyx †; and there are many reasons for adopting this view, as I explained in the Report on the 'Challenger' Crinoids ‡. In practice, however, Wachsmuth and Springer, like myself, found it more convenient to regard the arms as beginning with the first free plate beyond the calyx, and they described *Encrinus* as having but one radial followed by two brachials, the second axillary and bearing the arm-plates, which the older writers had regarded as brachials following a series of three radials.

In Zittel's 'Palæontology' § Schultze's views are adopted and extended to the Neocrinoids, so that the calyx of *Comatula* and *Pentacrinus*, *Encrinus* and *Millericrinus*, is described as having but one radial followed by two brachials. *Apiocrinus*, however, is said to have three radials, from which it would appear that in Zittel's opinion the first articular facet in this type is on the third or axillary radial. This, however, is not the case, as was pointed out by myself in 1881 ||, and more recently again by de Loriol ¶. In any well-preserved calyx of *Apiocrinus* which has the upper face of a first radial exposed, a definite facet for a muscular articulation of the usual character is plainly visible. This point is well shown in de Loriol's figure of *A. elegans* **. There is a perforated transverse ridge with muscular fossæ above it and a dorsal fossa

* *Op. cit.* part i. 1879, p. 27 (of separate copy).

† *Ibid.* part ii. 1881, p. 10.

‡ Part i. pp. 47, 48.

§ *Op. cit.* p. 339.

|| "On two new Crinoids from the Upper Chalk of Southern Sweden," Quart. Journ. Geol. Soc. 1881, vol. xxxvii. p. 134.

¶ *Op. cit.* p. 225.

** *Op. cit.* pl. xxxiii. figs. 2 a, 2 b, pl. xxxiv. figs. 6 a, 6 b.

which lodged the extensor ligament (muscle?). The plates of attachment for the flexor muscles between the first and second radials are in a more vertical position than the rest of the articular face, and when the second radials are in position five clefts are visible on the floor of the calyx, which were occupied during life by the five pairs of muscular bundles. These clefts are particularly well shown in Zittel's own figure of the interior of the cup of *Apiocrinus Parkinsoni**, while in de Loriol's more recent figure of the same species † they likewise appear, together with precisely similar clefts between the radial axillary and the two brachials which it bears. The existence of a muscular articulation is admitted in the latter case, and it will scarcely be any longer denied that there is a similar articulation between the first and second radial. It is a peculiar one no doubt, owing to the great size of the dorsal fossa in some species of *Apiocrinus*. But this is well developed in some species of *Millericrinus*, e. g. *M. ranvillensis*, and a regular gradational series may be traced from the most *Pentacrinus*-like forms of *Millericrinus* through *M. ranvillensis* to *Apiocrinus elegans*, and thence to forms like *A. Meriani* and others with large dorsal fossæ.

Even in these last there are distinct indications of a muscular articulation, while whenever the distal faces of the second radials or the proximal faces of the axillaries are visible they present a vertical articular ridge for a bifascial articulation, exactly as in *Antedon rosacea* and in most *Comatulæ* ‡. We find therefore that in the calyx of *Apiocrinus* there are two articular facets below that on the axillary radial, which is the first one admitted by Zittel; and if Schultze's nomenclature be followed, *Apiocrinus* must be described as having but one radial, like *Encrinus* and *Pentacrinus*. The same will be the case with every other Neocrinoid except *Guettardicrinus*, a genus which, as defined by d'Orbigny, is not admitted by Zittel; but de Loriol has pointed out that in this type there are no articular facets on either of the three radials, nor even on the distal faces of the second joints after the axillary §; and, in fact, it has not yet been determined what plate of the body of this type does bear the first facet.

If, then, Schultze's nomenclature is to be extended to the Neocrinoids, *Guettardicrinus* is the only type which can be said to have more than one radial.

Steinmann and Döderlein || admit that the arms *sensu stricto*

* *Op. cit.* p. 389, fig. 277 b.

† *Op. cit.* pl. xxx. figs. 1 a, 1 b.

‡ De Loriol, *op. cit.* pl. xxx. fig. 2 b, pl. xxxiii. fig. 2 a, pl. lvi. figs. 2, 2 c.

§ *Op. cit.* p. 219.

|| 'Elemente der Paläontologie,' Leipzig, 1888, p. 153.

begin immediately beyond the primary radials. But if the lower arm-plates form a part of the dorsal cup, those up to and including the first axillary are called radials, while their successors up to the next axillary retain their Müllerian name, distichals, those beyond them again being called distichals of the second order.

Ever since I began to write on the Crinoids, now some thirteen years ago, I have used this term distichals to denote the plates between the first and the second axillary (inclusive) of Crinoids with more than ten arms, whether these be free or united by interrarial plates; while the plates up to and including the third axillary, should such occur, have been called palmars. This method has been adopted by other writers on recent Crinoidea, and has been found to work well in practice, as it is obviously much shorter to say "distichals" than "radials of the second order" or "brachials of the first order." "Palmars" in like manner is a preferable term to "radials of the third order," and the succeeding axillaries, when present, may be conveniently called first, second, third postpalmars, &c. For purely descriptive purposes it is not often necessary, either for recent or for fossil Crinoids, to refer to more than three axillaries above the radials, viz. distichal, palmar, and postpalmar; and Messrs. Wachsmuth and Springer have agreed to use these terms for the future in their descriptions of Palæocrinoids.

It has also seemed desirable to arrive at some sort of agreement as to the nomenclature to be adopted for the plates between the basals and the first bifurcation in Crinoids with ten or more arms. Müller called them all radials in every Crinoid, and the same course has been adopted by de Loriol and myself; while other authors have endeavoured to distinguish between the first plate and its successors according to their ideas respecting the position of the first articular surface or the extent to which the outer plates are included in the dorsal cup. But it will be evident from what has been said above that neither of these criteria is a satisfactory one, and that there is consequently a great want of unanimity between different authors, and even in different parts of the same work, so that the result cannot but be most perplexing to the student. All the leading writers are agreed, however, that the arms really commence with the first plates above the primary radials, and not above the first axillaries, *i. e.* that the plates which are sometimes called the outer radials, situated between the primary radials and the distichals, are really arm-plates; while, as Zittel has pointed out, there are developmental reasons for considering this to be the case*.

* *Op. cit.* p. 339.

Under these circumstances it has been agreed between Messrs. Wachsmuth and Springer and myself to describe all Crinoids as possessing but one radial in each ray; and it can then be referred to without the prefix "primary," which has hitherto been necessary in comparing this plate with what we believe to be its homologue in Urchins and Stellerids. All plates beyond this which lie in a radial direction are arm-plates or brachials, those beyond the first axillary being called for descriptive purposes distichals, palmars, and postpalmars, as explained above. But it now becomes necessary to find some convenient descriptive name for the plates between the radial primaries and the distichals, which have hitherto been known as the outer radials in the Neocrinoids generally. It is difficult to find a rational one which shall have the merit of brevity, and we have therefore decided to revert to the purely empirical term "costals." This was invariably employed by J. S. Miller * to denote the second radials, where he did not call them arm-plates, as will appear from the subjoined table (p. 16).

Miller's terminology was not strictly logical, and one can hardly expect that it should have been so; but at any rate it served as a foundation for much valuable work, and I think it only right to employ one of his terms when this is possible without straining analogy too far. The plates which Miller sometimes called first costals and sometimes scapulae are far better described by Müller's name "radials;" but I think that we may fairly employ the names first and second costals for the second and third radials of Müller, now that it is agreed by every one that they are morphologically arm-joints.

In seven of the eight generic descriptions in which Miller used the term costals at all it was applied to plates in the direction of the rays, and in one genus only (*Cyathocrinus*) did he definitely give this name to interradial plates, and then in but three of its four species. It is somewhat unfortunate therefore that in his classical memoir on the Echinoidea Lovén should have proposed to specialize this name as denoting the primary interradial plates of the Echinoderm apical system, *i. e.* the genitals of Urchins and the basals of Crinoids †. I pointed this out in 1878 ‡, and Lovén, while admitting Miller's inconsistency, replied that "It has always been considered allowable to suggest the use in a strict sense of a term elsewhere vaguely applied" §. This is of course quite true; but the

* 'A Natural History of the Crinoidea,' Bristol, 1821.

† *Op. cit.* p. 73.

‡ Quart. Journ. Micr. Sci. 1878, vol. xviii, p. 363.

§ "On *Pourtalesia*, a Genus of Echinoidea," Kongl. Svenska Vetenskaps-Akademiens Handlingar, 1883, Bd. xix. no. 7, p. 64.

Nomenclature of { J. Müller.	Basals.	Parabasals.	First Radials.	Second Radials.	Third Radials.
Nomenclature of { Carpenter and de Loriol. <td data-bbox="267 286 367 560">Under-basals.</td> <td data-bbox="267 560 367 799">Basals.</td> <td data-bbox="267 799 367 1055">First Radials.</td> <td data-bbox="267 1055 367 1311">Second Radials.</td> <td data-bbox="267 1311 367 1555">Third Radials.</td>	Under-basals.	Basals.	First Radials.	Second Radials.	Third Radials.
Nomenclature of J. S. Miller.					
<i>Apiocrinus</i>	Pelvis.	First Costals.	Second Costals.	Scapulæ.
<i>Enerinus</i>	Pelvis.	First Costals.	Second Costals.	Scapulæ.
<i>Pentacrinus</i>	Pelvis.	First Costals.	Second Costals.	Scapulæ.
<i>Comatula</i>	First Costals.	Second Costals.	Scapulæ.
<i>Actinocrinus</i>	Pelvis.	First Costals.	Second Costals.	Scapulæ.
<i>Rhodocrinus</i>	Intercostals.	First Costals.	Second Costals.	Scapulæ.
<i>Platycrinus</i>	Pelvis.	Scapulæ.	Arm-plates.	Scapulæ.
<i>Cyathocrinus</i>	Costals, or Inter- costals in one species.	Scapulæ.	Arm-plates.	Arm-plates.
<i>Poteroocrinus</i>	Intercostals.	Scapulæ.	Arm-plates.	Arm-plates.
<i>Marsupites</i>	Intercostals or Costals?	Scapulæ.	Arm-plates.	Arm-plates.
Nomenclature now proposed. }	INFRABASALS.	BASALS.	RADIALS.	FIRST COSTALS.	SECOND COSTALS.

strict sense in which the term is to be used for the future should surely be that in which it was most generally used in the past. This is very far from being the case with Lovén's specialization of the term costals, as will be seen from the preceding table; and as his proposal has not been generally adopted by Echinologists, I think there can be no harm in employing Miller's name for plates which do lie in the direction of the rays of Crinoids, and were always called costals by him when not described as arm-plates, viz. those commonly known as the second radials. This being granted, it naturally follows that the axillary or third radials, the scapulæ of Miller, should be called the second costals; and these terms will be employed for the future by Messrs. Wachsmuth and Springer, Bather, and myself. Furthermore, in genera like *Metacrinus* and *Parisocrinus*, in which there may be four or five joints between the radial and the first axillary above it, the whole series, including the axillary, will in future be called the costals.

The use of this term also simplifies matters in another way. I pointed out in 1877*, and have done so frequently since, that the first two joints beyond every axillary of a multi-brachiate Neocrinoid are nearly always united, whether by syzygy or by bifascial articulation, in the same manner as the second and third radials. Now, however, we can say more briefly that there is generally the same mode of union between the first two free brachials and the first two distichals and palmars &c., when present, as between the first two costals. Thus, among the Palæocrinoidea this union is a syzygy in *Graphiocrinus* and *Scytalocrinus*. The same rule holds good in *Enerinus* (syzygy) and in *Apiocrinus*, *Millericrinus*, and *Bathycrinus* (articulation). Five of the eight recent species of *Pentacrinus* have the two costals, distichals, and palmars, and the first two free brachials respectively united by syzygy, while there are bifascial articulations between the two costals and the first pair of joints beyond them in each of the other three species. Some of the fossil Pentacrinidæ present indications of the same regularity, and it is also traceable in *Metacrinus*, though to a less extent, owing to its larger and more variable number of costals; and this is probably also the case in the Palæocrinoids with a similar character.

It is among the *Comatulæ*, however, that the regularity in question is most marked. Among the 120 species of *Antedon*

* "On the Genus *Actinometra*, Müll., with a Morphological Account of a new Species from the Philippine Islands," Trans. Linn. Soc., 2nd ser. Zool. vol. ii. p. 22.

noticed in the 'Challenger' Report there are but nine in which the first two joints beyond each successive axillary are not always united in the same manner as the two costals are. Thus in the three members of the *Elegans*-group the costals are united by syzygy, while the first two joints after each axillary are articulated. In the six members of the *Granulifera*-group the costals and the first two distichals are articulated bifascially. Five of the species have the corresponding palmars and brachials united by syzygy, while in the sixth this is replaced by a muscular articulation.

Among the eighty-four species of *Actinometra* the four members of the *Typica*-group have a syzygy between the two costals, palmars, postpalmars, and brachials respectively, while the first two distichals are articulated; and in the seven species of the *Fimbriata*-group the costals and the first pair of distichals are respectively united bifascially, while there is a muscular articulation between the first two joints after the distichal and all subsequent axillaries. The four members of the *Stelligera*-group again have the first two free brachials united by syzygy, while the corresponding joints of all the lower arm-divisions are articulated.

Excepting in these aberrant forms, therefore, the facts of Crinoid anatomy are in favour of the view that the plates called second and third radials by Müller really belong to the arms; and so I propose to abandon the use of R in the specific formulæ of the *Elegans*-, *Solaris*-, and *Typica*-groups*, and to substitute a *c*, indicating the costals, just as *d* stands for distichals and *p* for palmars. A glance of the illustrative formulæ given below, and especially those of *Actinometra solaris* and *A. paucicirra*, will show that this alteration makes them at once more simple and more symmetrical; and as it seems undesirable to have one *c* in the formulæ to indicate costals and another in the cirrus-notation, as proposed by Bell †, I propose to use *x*, *y*, *z* for the latter purpose instead of *a*, *b*, *c*. This has the further advantage of enabling us to write a simple *b*, and not *br*, to indicate the free brachials of the arms.

* See the Report on the 'Challenger' *Comatulæ*, pp. 53, 57.

† "An Attempt to apply a Method of Formulation to the Species of the *Comatulidæ*, with the Description of a new Species," Proc. Zool. Soc. Lond. 1882, p. 531. See also the Report on the 'Challenger' *Comatulæ*, pp. 43-50.

Illustrative Formulæ.

<i>Antedon elegans</i>	A. R. 3. 2. (2) $\frac{b}{c}$	becomes	A. $\frac{c}{2}$. 3. 2. (2) $\frac{y}{z}$.
— <i>inæqualis</i>	A. 3. $\frac{(p). br}{2} \cdot \frac{b}{b}$	„	A. 3. $\frac{(p). b}{2} \cdot \frac{y}{y}$.
— <i>porrecta</i>	A. 3. 2 $\left\{ (p). br \right\} \cdot \frac{b}{c}$	„	A. 3. 2 $\left\{ (p). b \right\} \cdot \frac{y}{z}$.
<i>Actinometra solaris</i>	a. R. $\frac{br}{2} \cdot \frac{ab}{ab}$	„	a. $\frac{c. b}{2} \cdot \frac{xy}{xy}$.
— <i>paucicirra</i>	a. R. $\frac{d. (p). br}{2} \cdot \left(\frac{a}{a}\right)$	„	a. $\frac{c. d. (p). b}{2} \cdot \left(\frac{x}{x}\right)$.
— <i>multibrachiata</i>	a. R. 3. $\frac{p. p' . . . p^{vi} br}{2} \cdot \frac{b}{a}$	„	a. $\frac{c}{2} \cdot 3 \frac{p. p' . . . p^{vi} b}{2} \cdot \frac{y}{x}$.
— <i>stelligera</i>	a. 2. 2. (2) $\cdot \frac{br}{2} \cdot \frac{bc}{ab}$	„	a. 2. 2. (2) $\cdot \frac{b}{2} \cdot \frac{yz}{xy}$.

5. The use of the term “Axillary.”

The term “axillary” was introduced by Müller* and defined as follows:—“Das dritte *radiale* hat nach oben zwei dachförmig geneigte Gelenkflächen für die beiden darauf sitzenden Arme. Ich nenne es deswegen *radiale axillare*, es ist Miller’s *Scapula*, dagegen nenne ich *brachialia axillaria* alle im Verlauf der Arme vorkommenden ähnlichen Glieder, auf denen zwei Theilungsarme aufsitzen.”

The term has been generally used in the Müllerian sense during the last forty years, *i. e.* only with reference to plates which serve as points of division in the rays and arms, whether these be free or incorporated into the more or less rigid dorsal cup. Bather, however, has recently extended its use in a manner which is scarcely advisable at present, since it is not as yet justified by anatomical research. He has applied the name to the “bifurcating piece” in *Iocrinus* which gives rise both to the right posterior ray and to the ventral sac †. The lowest of the series of plates supporting the ventral sac—that which rests on the left upper edge of the bifurcating piece, and is marked \times in Bather’s diagram ‡—is regarded by him as having “originated as a plate morphologically corresponding to an ordinary brachial;” and he

* “Ueber den Bau des *Pentacrinus caput Medusæ*,” Abhandl. Berlin. Akad. 1841 [1843], p. 202.

† Ann. & Mag. Nat. Hist. ser. 6, vol. v. 1890, p. 320.

‡ *Ibid.* pl. xiv. fig. 5.

distinguishes it accordingly as the "Brachianal." He states that "in size and position it is just like the adjacent arm-plate" *. But is this really the case? Is there the same articulation between its under surface and the bifurcating piece below it as between the latter and the arm-plate of the right posterior ray? This has yet to be demonstrated; and until such a demonstration has been given the term "axillary" should not be applied to the bifurcating piece, as has been done by Bather. Whatever be the merits of his theory, as applied to other *Fistulata*, there appear to me to be grave doubts respecting the correctness of his interpretation of the plate \times in *Iocrinus*. This is regarded by Wachsmuth and Springer as the first plate of the anal tube, and not in any way as a "special anal," or brachianal as Bather calls it; and if such be the case, the bifurcating piece on which it rests is not in any sense an axillary. Bather, however, not only calls it an axillary plate himself, but also represents the American authors and myself as having done the same, which is not the case. I did not state "that Wachsmuth and Springer homologize the lower half of the compound radial in *Dendrocrinus* with the upper axillary plate in *Iocrinus*." Neither did the American authors misquote me "as having suggested that the axillary plate of *Iocrinus* was an 'azygos' plate" †. Neither they nor I used the term "axillary" at all, so that there was no reason for Bather to represent us as having done so, more especially as we do not yet know that the plate in question is entitled to this name.

6. *Interambulacral and Adambulacral*s.

In Müller's classical memoir, "Ueber den Bau der Echinodermen," after discussing the views of de Blainville and A. Agassiz respecting the interambulacral plates of a Starfish ‡, he proposed to distinguish the marginal plates of the ambulacra from the remaining interambulacral plates by the name "adambulacral." Those plates situated between the ambulacra on the ventral surface of the body, which are so well developed in the pentagonal forms, were called intermediary interambulacral plates; and in a third category he placed the lower marginal plates of the rays. The term adambulacral proved to be a very convenient one, and it soon found its way into the current nomenclature both of zoology and of palæontology. It was not, however, adopted by A.

* *Ibid.* p. 330.

† *Ibid.* pp. 321, 322.

‡ Abhandl. d. Berlin. Akad. Jahrg. 1853 (1854), pp. 161, 162.

Agassiz, the plates generally known by this name being called interambulacral throughout his fine work on the North American Starfishes. Verrill used the same name for a while, but afterwards abandoned it in favour of adambulacral, and the same course was taken by Perrier. In a recent memoir on the development of the calcareous plates of *Asterias** Fewkes describes the plates in question as interambulacrals, with the remark, "adambulacrals of recent authors." The name, however, is much older than Fewkes implies, having been proposed by Müller and adopted by M. Sars, Salter, and Billings before 1860. Meek and Worthen and J. Hall used it in 1866-67, and, with the exceptions above mentioned, I know of no leading authority within the last twenty-five years who has used "interambulacral" to denote the marginal plates of the ambulacra of the Starfish †. Fewkes says with regard to them, "It may be as well to retain the old term, especially as they arise between ends of successive ambulacrals" ‡. This, however, is very far from being the real meaning of the old term as applied to the Urchins, for which group it was first employed. In a later communication again the two names *interambulacral* and *adambulacral* are used interchangeably by Fewkes §, on the ground that "the term interambulacral is not only the oldest, but is embryologically more accurate." As, however, there are at least three series of plates in Starfishes to which the name interambulacral has been applied, it would have conduced very considerably to the clearness of Fewkes's writings if he had followed the Müllerian plan of describing one of them as adambulacral; for when he speaks of interambulacrals it is sometimes difficult to determine to what series he is referring, and his use of the name for Müller's adambulacrals is the more likely to confuse, since his studies have led him to believe that "they are the same as the ambulacral" ||. The position of the plates in question is not the less interambulacral because Müller called them adambulacral, to distinguish them from the other two sets of interambulacral plates which are not so closely related to the ambulacra. These are called marginals and interbranchials

* Bull. Mus. Comp. Zoöl. 1888, vol. xvii. p. 37.

† They have been called adambulacrals by the following authors:—Bell, Döderlein, Eck, Fraas, Ganong, Ives, de Loriol, Lütken, Ludwig, Meneghini, S. A. Miller, Perrier, Rathbun, G. O. Sars, Studer, Sturtz, Verrill, Viguiet, Zittel.

‡ Bull. Mus. Comp. Zoöl. 1888, vol. xvii. p. 11.

§ "On the Serial Relationship of the Ambulacral and Adambulacral Calcareous Plates of the Starfishes," Proc. Boston Soc. Nat. Hist. 1889, vol. xxiv. p. 96.

|| Proc. Boston Soc. Nat. Hist. 1889, vol. xxiv. p. 105.

by Fewkes; but he would have been more in accordance with the rational terminology now current if he had used intermediary or interambulacral for interbrachial*, and had adopted Müller's use of adambulacral.

On p. 105 of his last paper † we read, "The plates in the Echinoids called adambulacrals which lie between the system of plates generally known as ambulacral are regarded as the same as the marginal plates of the starfish." This passage can only refer to the plates which are always called interambulacrals in the test of an Urchin, and I have been unable to discover that any author, except Fewkes, has ever called them adambulacral. Ludwig ‡, however, has pointed out that the ambulacral plates of an Urchin are in all probability homologous with the adambulacrals of a Starfish, and in his diagram of the skeleton of an Echinoid he marks these plates "Adambulacralia (sog. Ambulacralia)." Fewkes, on the other hand, speaks of "the so-called adambulacrals of sea-urchins" when he means the interambulacrals, auct., although no previous writer has employed the term in this sense, so that there was no reason for Fewkes to have done so. He accepts Ludwig's homology of these interambulacral plates (adambulacrals, Fewkes) with the marginals of the Starfish, as shown in the following table, copied from p. 106 of his memoir:—

STARFISH.	SEA-URCHIN.
1. Ambulacral rafters.	1. Wanting.
2. Peripheral ambulacrals §, generally called adambulacrals.	2. Ambulacrals.
3. Marginals.	3. Adambulacrals.

But he also remarks in a footnote, "The homologies here presented are essentially the same as those already published by Ludwig as far as the relationship between the ambulacrals of the starfish and the adambulacrals of the sea-urchin is concerned." There seems to be something wrong here, for it is clear that the adambulacrals of an Urchin cannot be homologous both with the ambulacrals of a Starfish (footnote) and also with its marginal plates (table).

It may be that a clerical error has been committed, the prefix *ad* being put in the wrong place in the footnote, and

* This term is not particularly applicable in the case of *Goniaster* and similar forms.

† Proc. Boston Soc. Nat. Hist. 1889, vol. xxiv. p. 105.

‡ "Entwicklungsgeschichte der *Asterina gibbosa*, Forbes," Zeitschr. f. wiss. Zool. 1882, Bd. xxxvii. p. 73.

§ These "peripheral ambulacrals" are also called interambulacrals by Fewkes, and in his figure on p. 99 they are lettered *ad*, Adambulacrals !!

that Fewkes meant to express his belief in Ludwig's homology between the *adambulacrals* of a Starfish and the *ambulacrals* of the Sea-urchin. But if this be the case the only plates in the Urchin to which the name *adambulacrals* can properly be applied are those generally known as *ambulacrals*. Why, then, does Fewkes repeatedly use it for the *interambulacrals*? He implies that other authors have done so before him, but gives no references; and, so far as I can make out, there are none to be found.

This is not the first occasion on which I have had to comment on the looseness of Fewkes's Echinoderm terminology and the confusion resulting therefrom. It is much to be regretted that when he took up a branch of zoology different from that in which he has gained a well-merited reputation he did not make himself better acquainted with its nomenclature, and thus enable his readers properly to appreciate the value of his observations and of the conclusions which he has drawn from them*. As it is, however, one is constantly perplexed by his vague and inaccurate use of terms which were clearly defined by Müller and have since had a very definite meaning for nearly all students of Echinoderms.

II. — *Notes on some West-Indian Longicorn Coleoptera, with Descriptions of new Genera and Species.* By C. J. GAHAN, M.A.

THESE notes chiefly refer to genera and species of Lacordaire's group Solenopterinae, and may, to some extent, be regarded as a revision of that group. Outside of the Solenopterinae the following genera and species are referred to or described:—

Stenodontes Chevrolati, sp. n.	Elaphidion mutatum, sp. n.
— damicornis, Linn.	— tomentosum, Chev.
— exsertus, Oliv.	Hornathus, g. n. (Ibidioninae).
— capra, Dej.	— cinctellus, sp. n.
— lævigatus, Beauv.	Phryneta verrucosa, Drury = P.
Mallodon bituberculatum, Beauv.	melanopectera, Thoms.

Stenodontes Chevrolati, sp. n.

S. damicorni verisimilis, sed differt capite subtus valde rugoso-punctato; elytris nitidis, vix punctulatis.

Hab. Cuba.

* Compare Hérouard, *loc. cit.*